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BY

K. M. CURTIS, M.A. D.I.C. D.Sc. F.L.S.
Mycologist, the Cawthron Institute, Nelson.

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A Die-back of *Pinus radiata* and *P. muricata* caused by the Fungus *Botryodiplodia pinea* (Desm.) Petr.

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[*Read before the Nelson Philosophical Society, 14th November, 1924; received by Editor, 26th November, 1924; issued separately, 6th March, 1926.*]

Plates 6, 7.

In August of this year the attention of the writer was drawn to the presence of what seemed to be an unrecorded disease of two species of *Pinus* in the Marlborough and Nelson Districts. In Nelson the disease occurred in trees in the town itself, while in Marlborough it was reported in the country, where valuable shelter-belts of *P. radiata* were said to be seriously threatened. On a visit being paid to Marlborough to investigate the matter it was found that, while in the case of certain shelter-belts it was necessary to take prompt steps to prevent extension of the disease, this disease was not responsible for the general dying-out of pines throughout the drier parts of Marlborough; this is rather due to the combined effect of drought, a deep shingly subsoil, and the inroads of various insect pests, notably the aphis *Chermes pini* Koch. The fungus disease, however, is sufficiently disastrous in the belts in which it is established to require attention, and a description of it is therefore now given.

General Appearance of Infected Trees.

The disease can readily be detected from a distance, its chief characteristic being the sharp contrast presented by the diseased and the healthy parts of the trees. The tip of the stem or of one or two of the higher branches dies, the disease then extending downwards for a length of as much as 20 ft. The stem is more often affected than the upper branches, and both are more often affected than branches low on the tree, although in one exceptional instance the lowest limb of a large tree was found to be wholly invated by the fungus.

The surface of an infected area is not sunken or distorted in any way, but if sufficient time has elapsed since infection took place for reproduction of the fungus to have occurred the pycnidia formed in this process will be found studding the host-surface (Plate 6, figs. 1 and 2). The pycnidia may occur singly, but usually they are arranged in ranks or groups, the ranks being either directed straight up and down the stem or, more frequently, arranged in the shape of a narrow horseshoe, directed downwards and enclosing in the upper part of the loop the scar of a needle-bearing shoot. As a rule the ranked or curved

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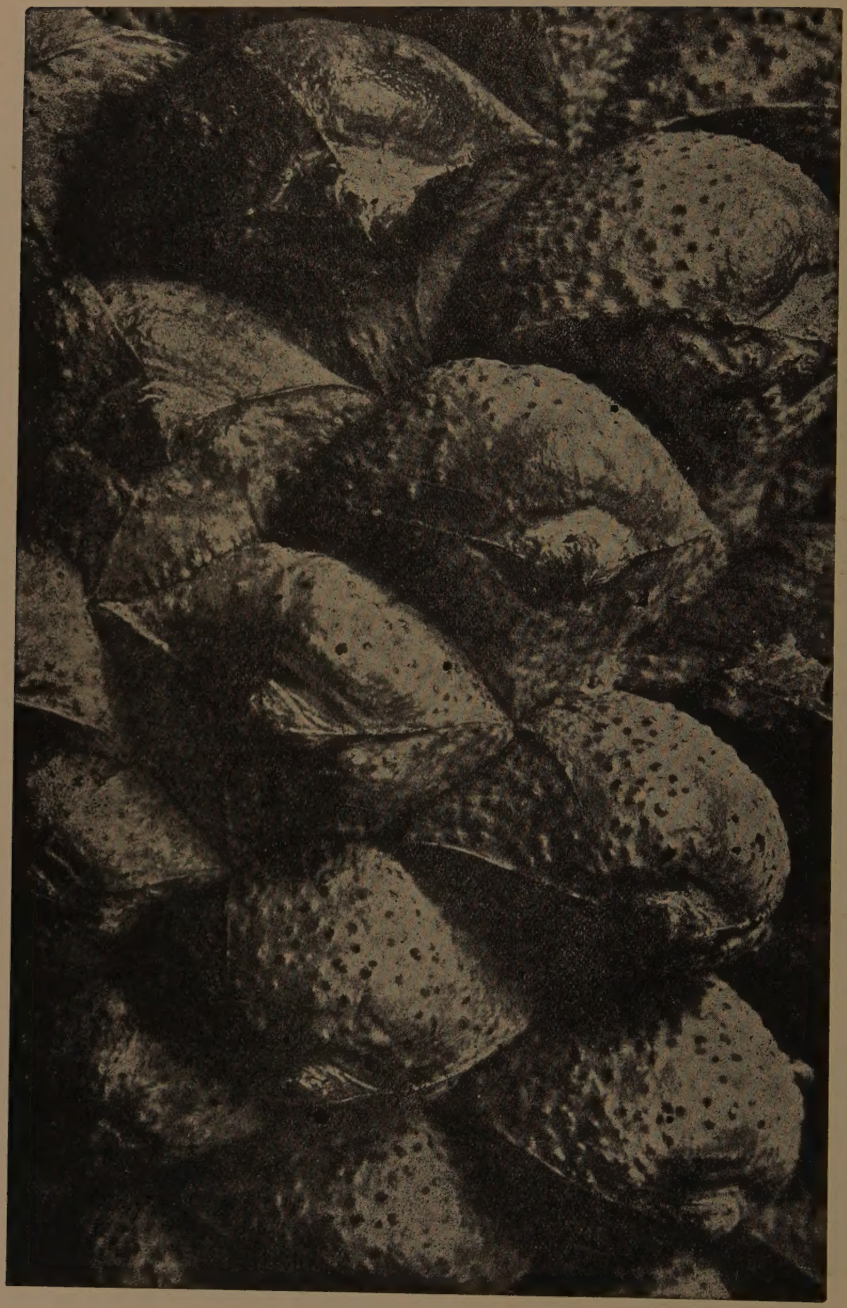
[*W. C. Davies, photo*

FIG. 1.—Tip of main stem of *Pinus radiata*, showing pycnidia of *Botryodiplodia pinea* (Desm.) Petr. on the surface. × 1.
FIG. 2.—As fig. 1, but an older specimen. Pycnidia in rows and in groups. × 1·5.



W. C. Davies, photo

Cone of *Pinus radiata* bearing scattered pycnidia on the exposed surface of the scales. × 2·5.

arrangement is still indicated, even when the whole surface is densely covered with pycnidia. The continued growth of the stem eventually separates the shoot-scars and tends to straighten the sides of the horseshoe.

The pycnidia are minute and black, and as they push up the epidermis they cause it first to appear white, and then rupture it into more or less elongated slits. On the splitting of the papery-white cuticle the upper surface of the pycnidia lies exposed. The length of the ranks of pycnidia varies from that of the diameter of a single pycnidium to 2 cm., while the width is frequently only that of one pycnidium, although it may be considerably greater.

INTERNAL APPEARANCE OF INFECTED TISSUE.

The simplest way to see the effect of the disease is to split the stem down the centre for a distance that includes several nodes. If the fungus is well established the bark and cortex are brown or practically black, the xylem has a cinereous tint, while the pith varies in shade from its normal rusty brown when only slightly invaded to pure black when the fungus is present in quantity. In nearly every case the tissue at the nodes where the cones are attached is more heavily infected than are the internodal regions, and it can often be seen that in a single stem infection has taken place at several successive nodes, a diseased stem- or branch-tip therefore frequently being the result of multiple infection.

The cones also become infected, but as a rule the fructifications of the fungus, instead of occurring in groups or rows, are scattered and appear singly as minute black dots piercing the epidermis (Plate 7).

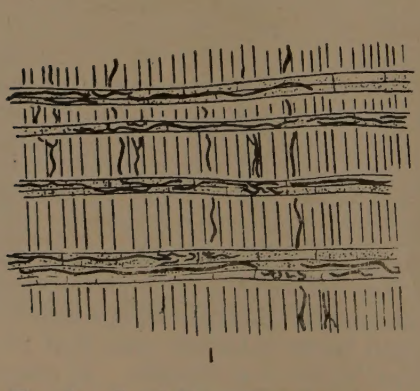
THE FUNGUS.

Vegetative Growth in the Host.—Whether a wound in the host-surface is necsesary to enable the fungus to gain entry in the first instance is not known; but, once established, it is an active parasite. Larvae of *Sirex juvencus* L. have been found in wood infected by *Botryodiplodia pinea*, and the death of the wood has been attributed to these larvae, the fungus being regarded as merely saprophytic; but, as it is quite common to find branches suffering from fungus attack without there being any trace of the grub, this suggestion is untenable.

As already mentioned, the path of infection can usually be traced back to a node, and then out into the short stems of the cones. It would seem that in some instances cones or cone-stems when young have been the original parts infected, and that the fungus has then worked down into the stem or branch. In other cases, however, infection seems to have taken place directly in the stem or branch involved.

The hyphae, at first hyaline, soon change to a fuliginous shade, and finally become quite black, especially when near the surface of the stem. The hyphae vary in width, but the older, coloured hyphae are usually the largest, attaining an extreme width of more than 10 micromillimetres. Here and there may be seen hyphae bearing on their surface a close arrangemnt of small papillate outgrowths, suggestive of rudimentary haustoria. These hyphae are intercellular in position and are usually hyaline. Growth in the cortex is vigorous, and it soon becomes a semi-stromatic mass of crushed dead cells bound together by numerous much-branched hyphae. Later, as the pycnidia are being formed, a true stroma is gradually developed beneath the epidermis, and eventually practically all the host-tissues outside the xylem become a black stromatic mass, which may extend for a considerable distance, parallel to the surface, beneath the seemingly still-intact bark.

The entry of the hyphae into the xylem takes place with few exceptions by way of the rays (text-figs. 1, 2). In radial sections of an infected area almost every cell of the rays, and particularly of the median albuminous ones, will be found to be permeated with the stout, dark strands of the fungus, and throughout the length of the ray numbers of slender branch-hyphae are given off into the tracheids, down whose length they can be traced for long distances. The hypha in a tracheid usually runs straight, but it gives off, at irregular intervals, further branch-hyphae, which as a rule pass directly through the pits in the lateral walls into neighbouring tracheids. Here they in turn commence a straight and usually downward course. Although hyphae in the tracheids are not as a rule as wide as those in the cortex, here and there one of greater width may be seen almost filling the tracheid containing it. The colour of these larger hyphae, like those in the cortex, deepens with age to a fuliginous shade or to black, eventually causing the wood to appear cinereous to the naked eye.



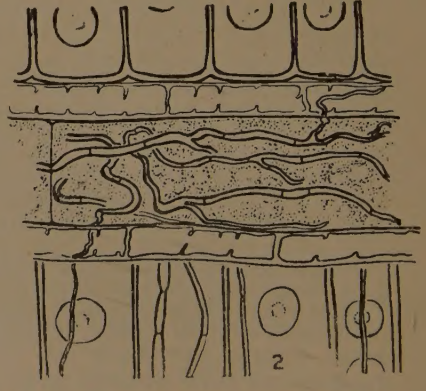
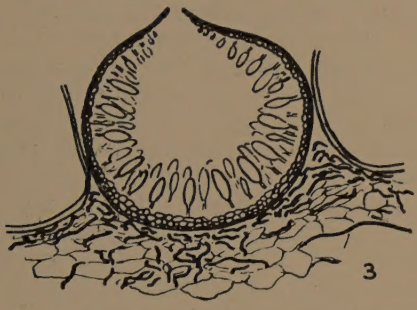
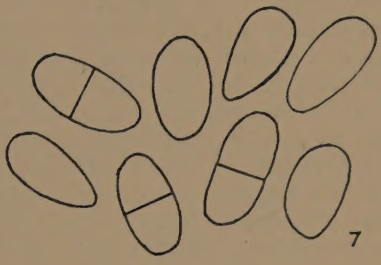


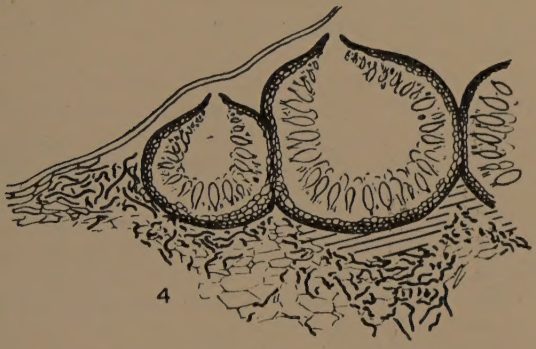
Fig. 1.—Semi-diagrammatic representation of invasion of the wood by hyphae travelling by way of the rays and thence into the tracheids.

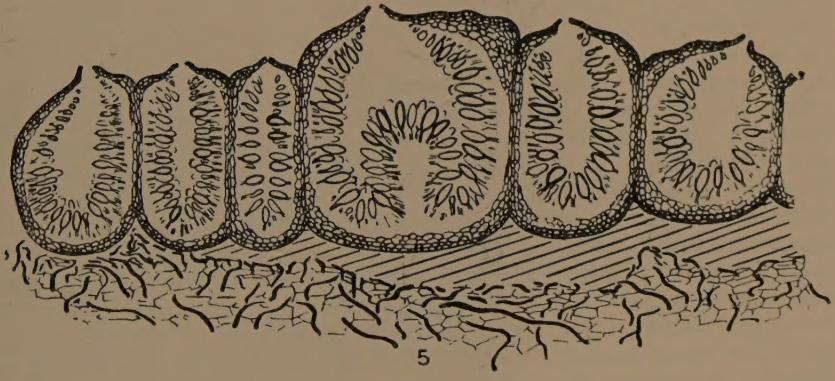
Fig. 2.—Portion of fig. 1 enlarged. The hyphae travel chiefly through the albuminous cells of the rays. × 352.

Reproduction.—When the disease was first noticed, in August of 1924, pycnidia were already present on the surface.









Figs. 3, 4, 5.—Pycnidia in different stages. In fig. 3 the pycnidium is single and has no stroma. In fig. 4 the pycnidia form part of a small group, and the beginning of a stroma is indicated in the area marked with parallel lines. In fig. 5 the pycnidia are part of a long row. A stroma is present, and one pycnidium is of the stromatic type with a single locule and a partial dissepiment. × 48.

Fig. 6.—Spores, young. × 352.

Fig. 7.—Spores, mature. × 352.

The spores in some of them were light brown in colour, but in most they were were still hyaline. Similar stages may still be

found in the original material as well as in that gathered in mid-November. The production of pycnidia thus continues for some time. The spores are seldom mature when the pycnidia first appear through the ruptured epidermis. Even in pycnidia that are known to be several months old most of the spores are still pale if not actually hyaline. All stages in complexity of pycnidial structure are to be found (text figs. 3, 4, 5). They may be simple, papillate, and more or less spherical, with the free surface perhaps a little flattened. Two or more may occur in a row or group and have their walls in contact. In the next stage of complexity, in which more pycnidia are usually present, the walls in contact are replaced by common walls, each pycnidium still having its own ostiole; a rudimentary or a well-developed stroma may or may not be present in this stage. In the final stage, which occurs in the largest pycnidial groups, the combined pycnidia are replaced by a stroma with a single locule, one or more ostioles, and one, several, or no partial dissepiments.

The simplest non-stromatic isolated pycnidia are to be found wherever pycnidial formation is only beginning. Later, adjoining these pycnidia, or in the region close by, stromatic pycnidia and chambered stromata are formed in close juxtaposition. An old row or group of pycnidia exhibits at any one time every grade of pycnidial development, the one basal stroma being common to all the pycnidia of the group, with the exception of the simplest younger ones, which in the ranked arrangement occur usually at either end of the row, and in the group arrangement at the periphery. Even for the youngest isolated members of the group, however, it is usually only a matter of time before they too are linked to the main body of the group by an extension of the common stromatic base. As already mentioned, this stromatic linking has not been found on the cones, where the pycnidia as a rule remain isolated from one another. The smaller size and the isolation of the cone-pycnidia are probably due to the greater hardness of the cones preventing the free ramification of the mycelium evident in the cortex of stem and branch, where, moreover, the hyphae are in direct communication with the water-supply of the xylem.

The size of the pycnidia varies from 250 × 250 to 800 × 800 micromillimetres. If they are prevented by mutual pressure from expanding, their height exceeds their width. On the other hand, in the complex type with the locular stroma the width is usually increased, and may be several times as great as the height. The ostiole is shortly papillate. The cells composing the walls of the pycnidium are, on the whole, thin-walled, angular to rounded, black on and near the surface, fuliginous in the intermediate region, quickly paling to hyaline in the interior.

The spores (pycnospores) are ellipsoid-obovate to cylindrical; the ends are rounded, the lower ones being usually narrower than the upper, at times markedly so. The colour of mature spores is fuliginous to fuscous, but they may be discharged when immature, in which case the colour is often not deeper than a

golden-fuliginous. The septation varies. In each row or group of pycnidia there are many in which only the non-septate *Sphaeropsis* type of spore is to be found, but if the material is kept until some of the pycnidia approach maturity, which may mean for several months, the older pycnidia show at least a small number of uniseptate spores. In certain cases the septate *Diplodia* type of spore can readily be found, but this is rare except when the material has been kept for a considerable time. As a rule it is unusual to find the septate spore in pycnidia on the cones, where the *Sphaeropsis* type predominates instead. Spores when mature range in size from 24–37 × 14–18 micromillimetres, the average being about 32–35 × 14–16 mmm. The sporophores are hyaline, and rather stout, attaining a size of from 7–12 × 2.5–3.5 mmm. with an average of 10 × 3.5 mmm.

Nomenclature.—The above description closely approximates that given by Kickx for *Diplodia pinea* (Desm.) Kickx* occurring on needles of *Pinus montana* and *P. silvestris* in France, Belgium, and Italy. Kickx, and Karsten also, reported a form of the same fungus in the bark of *P. silvestris* and of species of *Abies*. The only major point of difference between the fungus of Kickx and the present one is that Kickx, and also Desmazière, who originally described it, failed to notice the locular stromatic type of pycnidium occurring on stem and branch when the fructifications are advanced in age. But as the material described was on needles, that in the cortex being only noticed in passing, the significance of the omission is lessened, especially as the stromatic type does not occur regularly in the present disease. Morover, it is only within the last few years that the stromatic type has been recognized to be a usual phase in the development of the more common *Sphaeropsis* or *Diplodia* phases; and, as Desmazière first described his organism as long ago as 1842, the omission of these characteristics of the pycnidium is not surprising. Recently von Hoehnel has claimed that a fungus known earlier as *Phoma macrosperma* Karst. is merely *Diplodia pinea* (Desm.) Kickx at the stage when its spores are still hyaline. More recently again, Petrak, after insisting on the validity of the genus *Botryodiplodia* for members with grouped pycnidia and spores over a certain size, gave a detailed description of *Phoma macrosperma* Karst., adding to it details of structure which had not been given in the original description, and including in particular a greater spore-size than had been given for *Diplodia pinea* (Desm.) Kickx. This discrepancy he has overlooked, or has perhaps considered it insignificant (seeing that this character may show considerable variation), and, on the strength of his own previous assertions concerning the validity of the genus *Botryodiplodia,* has transferred *Diplodia pinea* (Desm.) Kickx to *Botryodiplodia pinea* (Desm.) Petr. Since then, although the generic limits of the

*As given in SACCARDO. *Syll. Fung.* vol. 3, p. 359, 1884.

Diplodiae are being more closely examined as knowledge of the developmental variations exhibited by members of the group is acquired, the genus *Botryodiplodia* as Petrak understands it still stands unchallenged.

The fungus attacking *Pinus radiata* and *P. muricata* in New Zealand is therefore referred to *Botryodiplodia pinea* (Desm.) Petr.

Control of the Disease.

As the fungus as a rule works downwards from the tip of the stem or branches, control of the disease requires only the removal and destruction of the parts infected. The mycelium may reach some inches below the fructifications, and also below the lowest sign of unhealthiness in the tree; the cut should therefore be made about 2 ft. below the lowest sign of the disease, the cut surface being then protected from parasites by a coating of Stockholm tar.

Literature Cited.

1884. P. A. Saccardo. *Sylloge Fungorum*, vol. 3, p. 359.

1913. T. Petch. Repr. from *Annals Royal Bot. Gardens Peradeniya*, vol 4, p. 445. (Ref. consulted : *Zeit. f. Pflanzenkrankheiten*, vol. 23, p. 242, 1913.)

1914. J. J. Taubenhaus. *Phytopathology*, vol. 4, p. 47.

1915. ——*Amer. Jour. Bot.*, vol. 2, pp. 324–31. Review in *Centralbl. f. Bakt. Parasitenk. und Infektionskr.*, 2 Abt., 51 Bd., p. 527.

1915. F. von Hoehnel. *Sitzb. Ak. Wiss Wien*, vol. 123, p. 84.

1919. W. B. Grove. *Journ. Bot.*, vol. 57, pp. 206–10. (Ref. consulted: *Bot. Abstracts* vol 3, p. 365, 1920.)

1922. F. Petrak. *Annales Mycologici*, vol. 20, pp. 306–8.

1923. —— *Annales Mycologici*, vol. 21, p. 332.

R. W. Stiles & Co., Printers, Waimea Street, Nelson—45922

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